A Novel View on Universal Mobile Telecommunication System (UMTS) in the Wireless and Mobile Communication Environment

Dr.S.S.Riaz Ahamed
Principal, Sathak Institute of Technology, Ramanathapuram,TamilNadu, India-623501.
Email:ssriaz@yahoo.com

Abstract

The Universal Mobile Telecommunication System (UMTS) is a third generation (3G) mobile communications system that provides a range of broadband services to the world of wireless and mobile communications. The UMTS delivers low-cost, mobile communications at data rates of up to 2 Mbps. It preserves the global roaming capability of second generation GSM/GPRS networks and provides new enhanced capabilities. The UMTS is designed to deliver pictures, graphics, video communications, and other multimedia information, as well as voice and data, to mobile wireless subscribers. UMTS also addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile communications sky. The new network increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard. UMTS allows many more applications to be introduced to a worldwide base of users and provides a vital link between today's multiple GSM systems and the ultimate single worldwide standard for all mobile telecommunications, International Mobile Telecommunications–2000 (IMT–2000).

Keywords: *Code Division Multiple Access (CDMA), Radio Access Network (RAN), Base Station Subsystem (BSS),Network and Switching Subsystem (NSS), Operations Support System (OSS),Base Station Controller (BSC), Base Transceiver Station (BTS), Transcoder and Rate Adapter Unit (TRAU), Operation and Maintenance Centers (OMCS), Packet Data Networks (PDNS), Virtual Home Environment (VHE), Radio Network Systems (RNSS), Transmission Power Control (TPC), Subscriber Identity Module (SIM)*

1. INTRODUCTION

UMTS stands for *Universal Mobile* Telecommunications *System.* UMTS is one of the emerging mobile phone technologies known as third-generation, or *3G*. Third-generation systems are designed to include such traditional phone tasks as calls, voice mail, and paging, but also new technology tasks such as Internet access, video, and SMS, or text messaging. One of the main benefits of UMTS is its speed. Current rates of transfer for broadband information are 2 Mbits a second. This speed makes possible the kind of streaming video that can support movie downloads and video conferencing. In a sense, UMTS makes it possible for you to enjoy all of the functionality of your home computer while you are roaming. By combining wireless and satellite cellular technologies, UMTS takes advantage of all existing options to result in the Holy Grail of 3G presentation: seamless transitions between WiFi and satellite[1][5][10]-[15].

UMTS went live as a network for the first time in Japan in 2001. Austria had its own network two years later. A handful of other European countries joined the UMTS bandwagon in the next two years, with South Africa and a few other African countries soon following suit. The U.S. has employed UMTS networks in several large cities, and the number is steadily growing.

UMTS is based on the Global System for Mobile (GSM) standard, which is the gold standard in Europe and more than 120 countries worldwide. In fact, UMTS is sometimes referred to as *3GSM*. The two systems are not compatible, however. UMTS is incompatible with GSM. Some phones are dual GSM/UMTS phones, but unless that exciting new mobile phone or handset that you can't wait to get your hands on has that kind of duality built in, you will only be able to utilize one mode, the one that came with the device.The UMTS takes a phased approach toward an all-IP network by extending second generation (2G) GSM/GPRS networks and using Wide-band Code Division Multiple Access (CDMA) technology. Handover capability between the UMTS and GSM is supported. The GPRS is the convergence point between the 2G technologies and the packet-switched domain of the 3G UMTS [3][7][13].

2. FEATURES

UMTS, using W-CDMA, supports up to 14.0 Mbit/s data transfer rates in theory (with HSDPA), although at the moment users in deployed networks can expect a transfer rate of up to 384 kbit/s for R99 handsets, and 7.2 Mbit/s for HSDPA handsets in the downlink connection. This is still much greater than the 9.6 kbit/s of a single GSM error-corrected circuit switched data channel or multiple 9.6 kbit/s channels in HSCSD (14.4 kbit/s for CDMAOne), and—in competition to other network technologies such as CDMA2000, PHS or WLAN—offers access to the World Wide Web and other data services on mobile devices.

Precursors to 3G are 2G mobile telephony systems, such as GSM, IS-95, PDC, PHS and other 2G technologies deployed in different countries. In the case of GSM, there is an evolution path from 2G, to GPRS, also known as 2.5G. GPRS supports a much better data rate (up to a theoretical maximum of 140.8 kbit/s, though typical rates are closer to 56 kbit/s) and is packet switched rather than connection orientated (circuit switched). It is deployed in many places where GSM is used. E-GPRS, or EDGE, is a further evolution of GPRS and is based on more modern coding schemes. With EDGE the actual packet data rates can reach around 180 kbit/s (effective). EDGE systems are often referred as "2.75G Systems".

Since 2006, UMTS networks in many countries have been or are in the process of being upgraded with High Speed Downlink Packet Access (HSDPA), sometimes known as 3.5G. Currently, HSDPA enables downlink transfer speeds of up to 7.2 Mbit/s. Work is also progressing on improving the uplink transfer speed with the High-Speed Uplink Packet Access (HSUPA). Longer term, the 3GPP Long Term Evolution project plans to move UMTS to 4G speeds of 100 Mbit/s down and 50 Mbit/s up, using a next generation air interface technology based upon Orthogonal frequency-division multiplexing[5]-[21].

3. SERVICES

The services are divided into four main classes:

1. Bearer Services
2. Tele services
3. Supplementary Services
4. Service Capabilities

Let's see each of them in detailed manner below

Bearer Services:

Bearer services in UMTS are negotiable (unlike GSM where they are not) and can be used flexibly by applications. Bearer services provide the capability for information transfer between access points and only lower layer functions. Bearer services are characterized by a set of end-to-end characteristics with requirements on QoS. QoS (or Quality of Service) is the quality of the service that has been requested. The service characteristics includes things like traffic type, supported bit rates and the quality of information. These parameters are negotiated when a connection is being established. If the network is unable to provide the required QoS, it will re-negotiate the QoS depending on what is available. After the connection has been established, if there is a need then these parameters can be re-negotiated again.

Teleservices

Teleservices provide the full capabilities for communications by means of terminal equipment, network functions and possibly functions provided by dedicated centres. Basically it is a service that provides complete end-to-end capability for communication between mobile users according to standards. Teleservices contain both single media and multimedia services. Some of the teleservices are listed below

- Speech/Telephony
- Emergency Calls
- Short Message Service - Point to Point (SMS-PP)
- Short Message Service - Cell Broadcast (SMS-CB)
- Internet Access

Teleservices utilizes the bearer services provided by lower layers. The Bearer Services and the Teleservices are not coupled to each other so as to aid independent development and changes to one may not necessarily mean changes to other.

Supplementary Services (SS)

A supplementary service modifies or supplements a basic telecommunication service. Consequently, it cannot be offered to a user as a stand alone service. A stand alone service can be either Bearer Service or Teleservice but cannot be Supplementary service. It shall be offered together or in association with a basic telecommunication service. The same supplementary service may be applicable to a number of basic telecommunication services. Also, one basic telecommunication service may use several SS simultaneously.

The following is list of some of the supplementary services,

- Call Forwarding
- Call Deflection
- Call Waiting
- Call Hold
- Call Restriction and Call barring
- Number Identification

Service Capabilities

Services Capability Features are open, technology independent building blocks accessible via a standardized application interface. This interface shall be applicable for a number of different business and applications domains (including besides the telecommunication network operators also service provider, third party service providers acting as HE-VASPs, etc.). All of these businesses have different requirements, ranging from simple telephony and call routing, virtual private networks, fully interactive multimedia to using UE based applications. Since the API is standardized but not the services, Mobile operators can utilize the API to build unique value-added services.

Two different types of service capability features can be distinguished,

- *Framework service capability features:* these shall provide commonly used utilities, necessary for the non-framework service capability features to be accessible, secure, resilient and manageable.
- *Non-Framework service capability features:* these shall enable the applications to make use of the functionality of the underlying network capabilities (e.g. User Location service capability features).

Examples of Framework Service Capability features are

- User-Network Authentication
- Application-Network Authentication
- User-Application Authentication
- Authorization

- Application-Network Authorization
- User-Application Authorization
- Registration
- Discovery

Examples of Non-Framework service capability features are

- Security/Privacy
- Address Translation
- Location
- User Status
- Terminal Capabilities
- Messaging
- Data Download
- User Profile Management
- Charging

UMTS network services have different QoS classes for four types of traffic:
Conversational class (voice, video telephony, video gaming)
Streaming class (multimedia, video on demand, webcast)
Interactive class (web browsing, network gaming, database access)
Background class (email, SMS, downloading)

UMTS will also have a Virtual Home Environment (VHE). It is a concept for personal service environment portability across network boundaries and between terminals. Personal service environment means that users are consistently presented with the same personalized features, User Interface customization and services in whatever network or terminal, wherever the user may be located. UMTS also has improved network security and location based services[2][4][13]-[19].

4. NETWORK ARCHITECTURE

UMTS (Rel. '99) incorporates enhanced GSM Phase 2+ Core Networks with GPRS and CAMEL. This enables network operators to enjoy the improved cost-efficiency of UMTS while protecting their 2G investments and reducing the risks of implementation.

In UMTS release 1 (Rel. '99), a new radio access network UMTS terrestrial radio access network (UTRAN) is introduced. UTRAN, the UMTS radio access network (RAN), is connected via the Iu to the GSM Phase 2+ core network (CN). The Iu is the UTRAN interface between the radio network controller (RNC) and CN; the UTRAN interface between RNC and the packet-switched domain of the CN (Iu–PS) is used for PS data and the UTRAN interface between RNC and the circuit-switched domain of the CN (Iu–CS) is used for CS data.

"GSM–only" mobile stations (MSs) will be connected to the network via the GSM air (radio) interface (Um). UMTS/GSM dual-mode user equipment (UE) will be connected to the network via UMTS air (radio) interface (Uu) at very high data rates (up to almost 2 Mbps). Outside the UMTS service area, UMTS/GSM UE will be connected to the network at reduced data rates via the Um.

Maximum data rates are 115 kbps for CS data by HSCSD, 171 kbps for PS data by GPRS, and 553 kbps by EDGE. Handover between UMTS and GSM is supported, and handover between UMTS and other 3G systems (e.g., multicarrier CDMA [MC–CDMA]) will be supported to achieve true worldwide access.

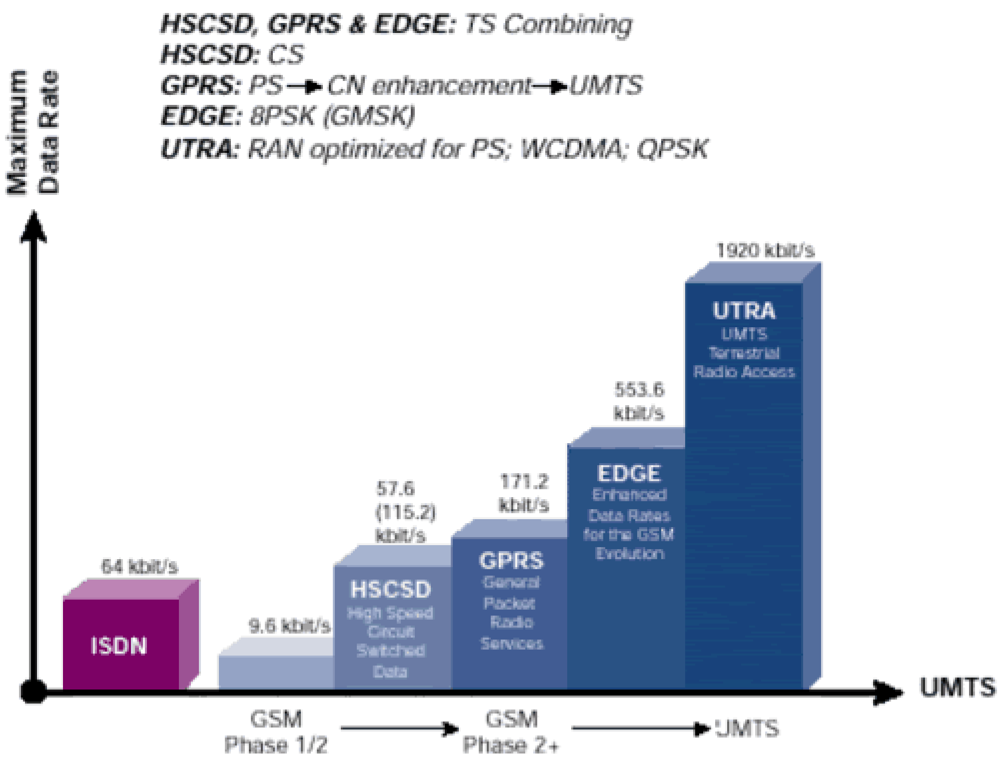

Figure 1. Transmission Rate

The public land mobile network (PLMN) described in UMTS Rel. ’99 incorporates three major categories of network elements:

- GSM Phase 1/2 core network elements: mobile services switching center (MSC), visitor location register (VLR), home location register (HLR), authentication center (AC), and equipment identity register (EIR)
- GSM Phase 2+ enhancements: GPRS (serving GPRS support node [SGSN] and gateway GPRS support node [GGSN]) and CAMEL (CAMEL service environment [CSE])
- UMTS specific modifications and enhancements, particularly UTRAN

Network Elements from GSM Phase ½

The GSM Phase 1/2 PLMN consists of three subsystems: the base station subsystem (BSS), the network and switching subsystem (NSS), and the operations support system (OSS). The BSS consists of the functional units: base station controller (BSC), base transceiver station (BTS) and transcoder and rate adapter unit (TRAU). The NSS consists of the functional units: MSC, VLR, HLR, EIR, and the AC. The MSC provides functions such as switching, signaling, paging, and inter–MSC handover. The OSS consists of operation and maintenance centers (OMCs), which are used for remote and centralized operation, administration, and maintenance (OAM) tasks.

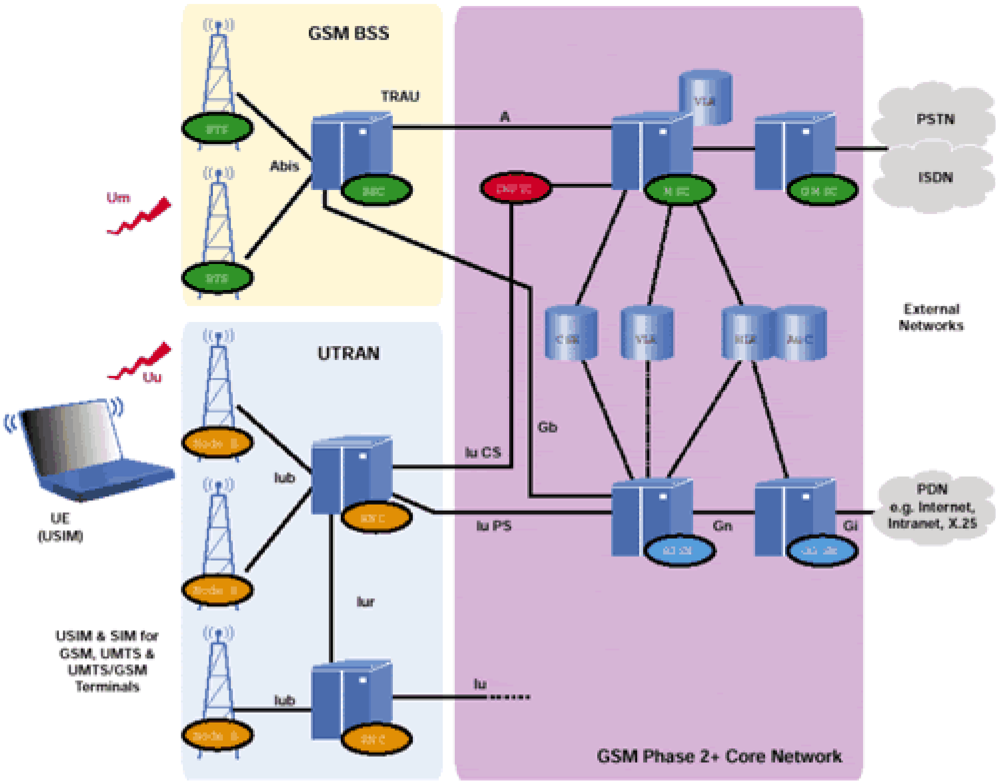

Figure 2. UMTS Phase 1 Network

Network Elements from GSM Phase 2+

GPRS

The most important evolutionary step of GSM toward UMTS is GPRS. GPRS introduces PS into the GSM CN and allows direct access to packet data networks (PDNs). This enables high–data rate PS transmission well beyond the 64 kbps limit of ISDN through the GSM CN, a necessity for UMTS data transmission rates of up to 2 Mbps. GPRS prepares and optimizes the CN for high–data rate PS transmission, as does UMTS with UTRAN over the RAN. Thus, GPRS is a prerequisite for the UMTS introduction.

Two functional units extend the GSM NSS architecture for GPRS PS services: the GGSN and the SGSN. The GGSN has functions comparable to a gateway MSC (GMSC). The SGSN resides at the same hierarchical level as a visited MSC (VMSC)/VLR and therefore performs comparable functions such as routing and mobility management.

CAMEL

CAMEL enables worldwide access to operator-specific IN applications such as prepaid, call screening, and supervision. CAMEL is the primary GSM Phase 2+ enhancement for the introduction of the UMTS virtual home environment (VHE) concept. VHE is a platform for flexible service definition (collection of service creation tools) that enables the operator to modify or enhance existing services and/or define new services. Furthermore, VHE enables worldwide access to these operator-specific services in every GSM and UMTS PLMN and introduces location-based services (by interaction with GSM/UMTS mobility management). A CSE and a new common control signaling system 7 (SS7) (CCS7) protocol, the CAMEL application part (CAP), are required on the CN to introduce CAMEL.

Network Elements from UMTS Phase 1

As mentioned above, UMTS differs from GSM Phase 2+ mostly in the new principles for air interface transmission (W–CDMA instead of time division multiple access [TDMA]/frequency division multiple access [FDMA]). Therefore, a new RAN called UTRAN must be introduced with UMTS. Only minor modifications, such as allocation of the transcoder (TC) function for speech compression to the CN, are needed in the CN to accommodate the change. The TC function is used together with an interworking function (IWF) for protocol conversion between the A and the Iu–CS interfaces.

UTRAN

The UMTS standard can be seen as an extension of existing networks. Two new network elements are introduced in UTRAN, RNC, and Node B. UTRAN is subdivided into individual radio network systems (RNSs), where each RNS is controlled by an RNC. The RNC is connected to a set of Node B elements, each of which can serve one or several cells [1]-[6].

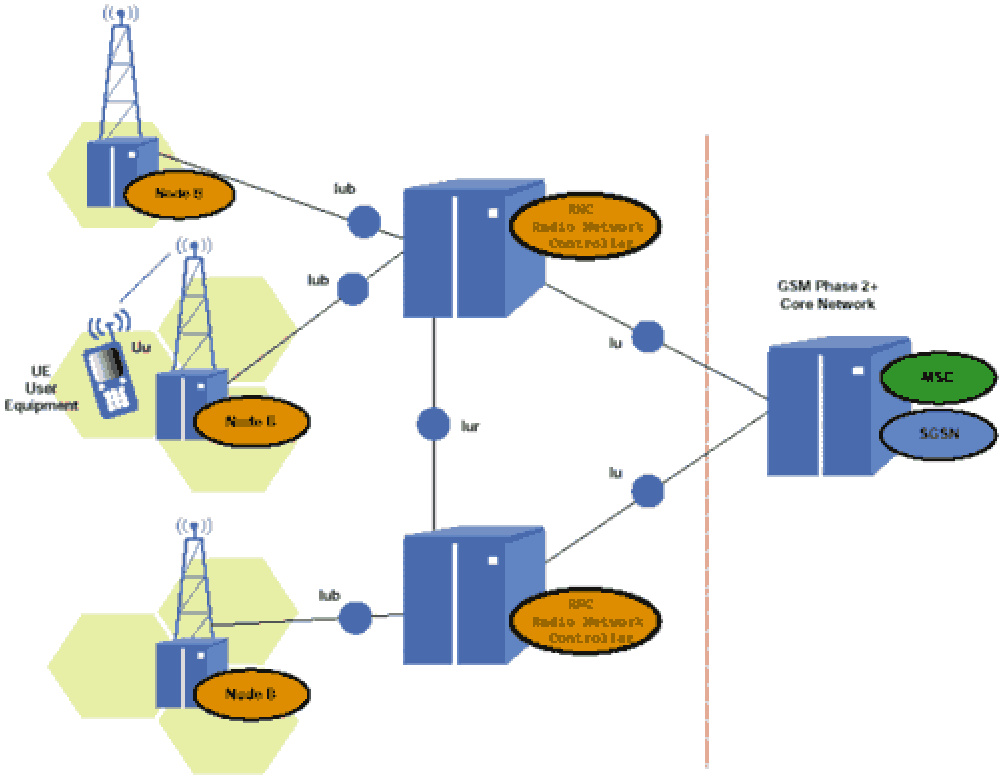

Figure 3. UMTS Phase 1: UTRAN

Existing network elements, such as MSC, SGSN, and HLR, can be extended to adopt the UMTS requirements, but RNC, Node B, and the handsets must be completely new designs. RNC will become the replacement for BSC, and Node B fulfills nearly the same functionality as BTS. GSM and GPRS networks will be extended, and new services will be integrated into an overall network that contains both existing interfaces such as A, Gb, and Abis, and new interfaces that include Iu, UTRAN interface between Node B and RNC (Iub), and UTRAN interface between two RNCs (Iur). UMTS defines four new open interfaces:

- Uu: UE to Node B (UTRA, the UMTS W–CDMA air interface
- Iu: RNC to GSM Phase 2+ CN interface (MSC/VLR or SGSN)
  - Iu-CS for circuit-switched data
  - Iu-PS for packet-switched data
- Iub: RNC to Node B interface
- Iur: RNC to RNC interface, not comparable to any interface in GSM

The Iu, Iub, and Iur interfaces are based on ATM transmission principles.

The RNC enables autonomous radio resource management (RRM) by UTRAN. It performs the same functions as the GSM BSC, providing central control for the RNS elements (RNC and Node Bs).

The RNC handles protocol exchanges between Iu, Iur, and Iub interfaces and is responsible for centralized operation and maintenance (O&M) of the entire RNS with access to the OSS. Because the interfaces are ATM–based, the RNC switches ATM cells between them. The user's circuit-switched and packet-switched data coming from Iu–CS and Iu–PS interfaces are multiplexed together for multimedia transmission via Iur, Iub, and Uu interfaces to and from the UE.

The RNC uses the Iur interface, which has no equivalent in GSM BSS, to autonomously handle 100 percent of the RRM, eliminating that burden from the CN. Serving control functions such as admission, RRC connection to the UE, congestion and handover/macro diversity are managed entirely by a single serving RNC (SRNC).

If another RNC is involved in the active connection through an inter–RNC soft handover, it is declared a drift RNC (DRNC). The DRNC is only responsible for the allocation of code resources. A reallocation of the SRNC functionality to the former DRNC is possible (serving radio network subsystem [SRNS] relocation). The term controlling RNC (CRNC) is used to define the RNC that controls the logical resources of its UTRAN access points.

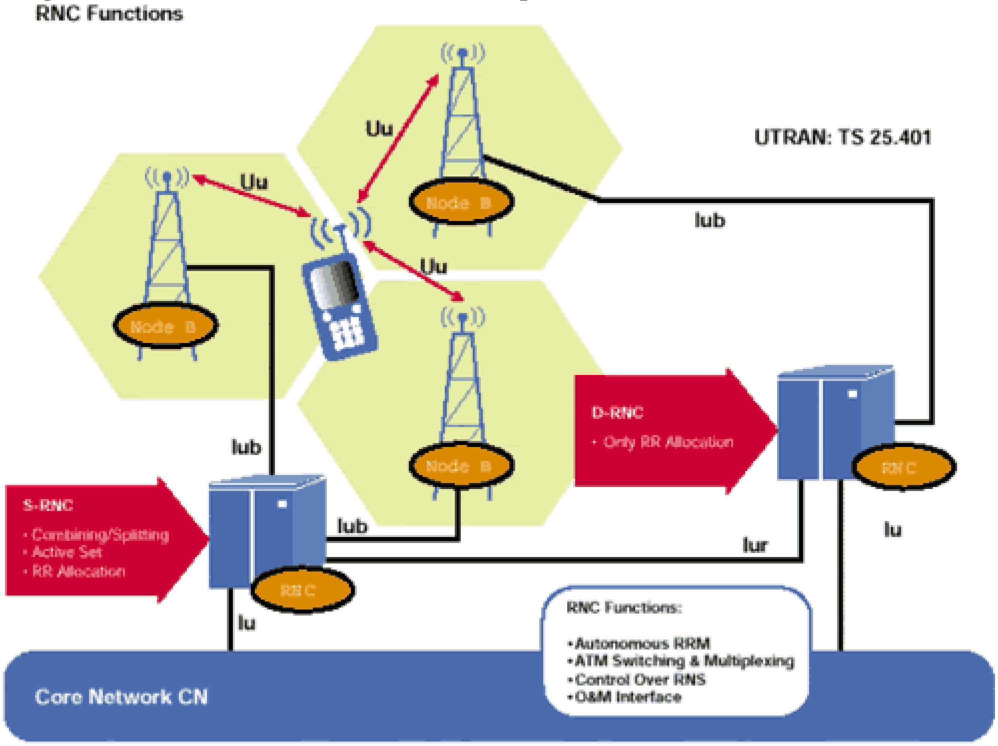

Figure 4. RNC Functions

Node B

Node B is the physical unit for radio transmission/reception with cells. Depending on sectoring (omni/sector cells), one or more cells may be served by a Node B. A single Node B can support both FDD and TDD modes, and it can be co-located with a GSM BTS to reduce implementation costs. Node B connects with the UE via the W–CDMA Uu radio interface and with the RNC via the Iub asynchronous transfer mode (ATM)–based interface. Node B is the ATM termination point.

The main task of Node B is the conversion of data to and from the Uu radio interface, including forward error correction (FEC), rate adaptation, W–CDMA spreading/despreading, and quadrature phase shift keying (QPSK) modulation on the air interface. It measures quality and strength of the connection and determines the frame error rate (FER), transmitting these data to the RNC as a measurement report for handover and macro diversity combining. The Node B is also responsible for the FDD softer handover. This micro diversity combining is carried out independently, eliminating the need for additional transmission capacity in the Iub.

The Node B also participates in power control, as it enables the UE to adjust its power using downlink (DL) transmission power control (TPC) commands via the inner-loop power control on the basis of uplink (UL) TPC information. The predefined values for inner-loop power control are derived from the RNC via outer-loop power control.

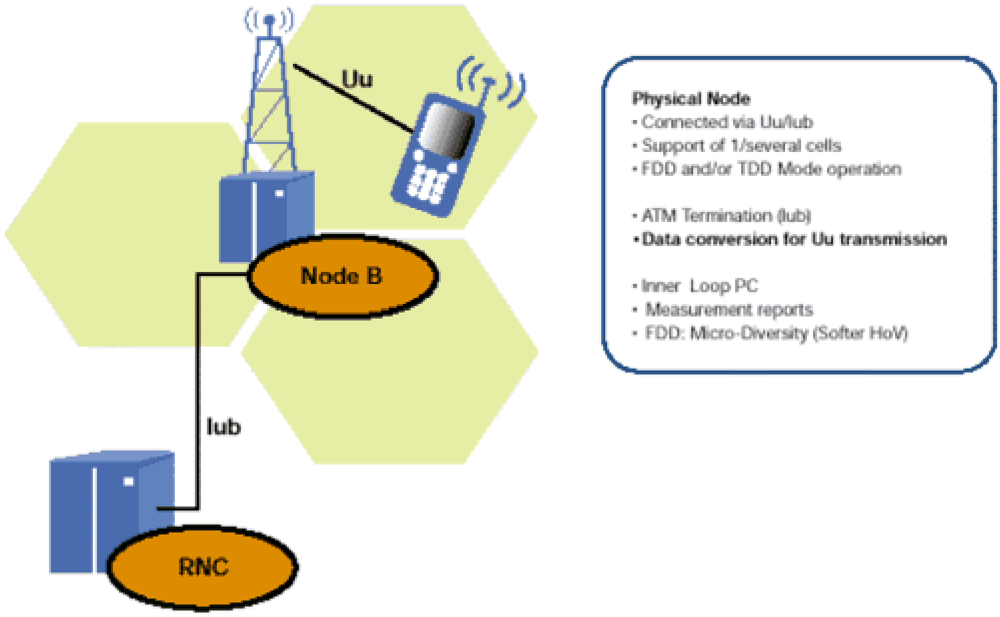

Figure 5. Node B Overview

UMTS UE

The UMTS UE is based on the same principles as the GSM MS—the separation between mobile equipment (ME) and the UMTS subscriber identity module (SIM) card (USIM). Figure shows the user equipment functions. The UE is the counterpart to the various network elements in many functions and procedures [9]-[21].

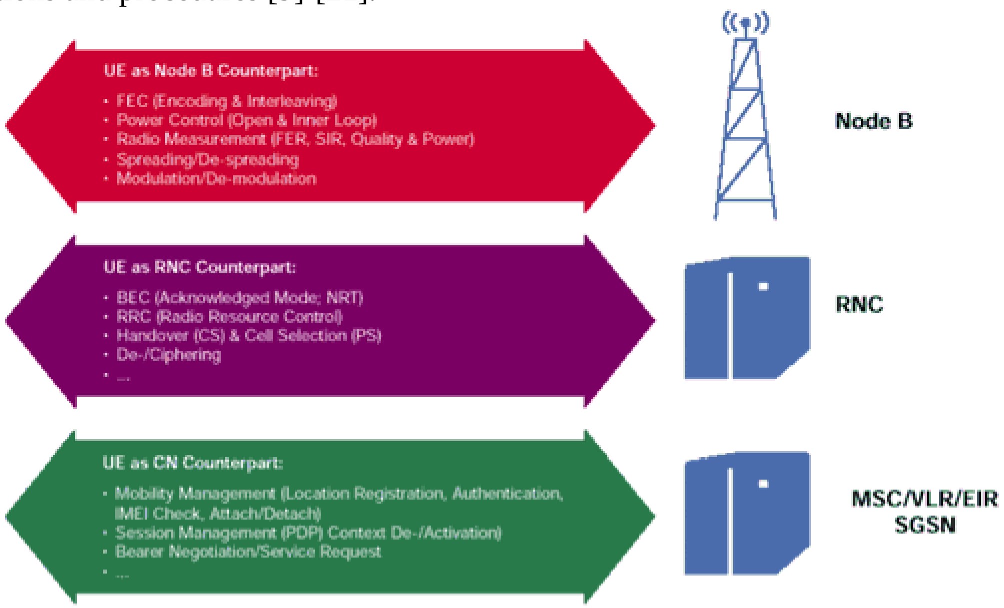

Figure 6. UE Functions

5. CONCLUSION

UMTS phones (and data cards) are highly portable—they have been designed to roam easily onto other UMTS networks (assuming your provider has a roaming agreement). In addition, almost all UMTS phones (except in Japan) are UMTS/GSM dual-mode devices, so if a UMTS phone travels outside of UMTS coverage during a call the call may be transparently handed off to available GSM coverage. Roaming charges are usually significantly higher than regular usage charges.Compared to GSM, UMTS networks initially required a higher base station density. For fully-fledged UMTS incorporating video on demand features, one base station needed to be set up every 1–1.5 km (0.62–0.93 mi). This was the case when only the 2100 MHz band was being used, however with the growing use of lower-frequency bands (such as 850 and 900 MHz) this is no longer so. This has led to increasing rollout of the lower-band networks by operators since 2006. As UMTS gains in credibility and functionality, experts believe it will overtake GSM as the industry standard. UMTS is already able to operate at a higher frequency than GSM.

6. REFERENCES

[1] E. Dahlman, B. Gudmundson, M. Nilsson, and J. Sköld, UMTS/IMT-2000 based on Wideband CDMA, IEEE Communications Magazine, vol. 36, issue 9, September 1998, pp. 70- 80.

[2] E. Dahlman, P. Beming, J. Knutsson, F. Ovesjö, M. Persson, and C. Robol, WCDMA - The radio interface for future mobile multimedia communications, IEEE Transactions on Vehicular Technology, vol. 47, issue 4, November 1998, pp. 1105 - 1117.

[3] A. Fukasawa, T. Sato, Y. Takizawa, T. Kato, M. Kawabe, R. E. Fisher, Wideband CDMA System for personal radio communications, IEEE Communications Magazine, vol. 34, issue 10, October 1996, pp. 116-123.

[4] T. Iwai, K. Kobayshi, Y. Nakasha, T. Miyashita, S. Ohara, K. Joshin, 42% high-efficiency two-stage HBT power-amplifier MMIC for W-CDMA cellular phone systems, IEEE Transactions on Microwave Theory and Techniques, vol. 48, issue 12, December 2000, pp. 2567-2572.

[5] K. Laird, N. Wannett, S. Buljore, A Peak-to-Average power reduction for third generation CDMA reverse link, Vehicular Technology Conference, 1999 IEEE 49th, vol. 1, Houston (Texas, U.S.A.) 16-20 May 1999, pp. 501-555.

[6] Christian Bettstetter et. all : IEEE Communications Survey Magazine Third Quarter, 1999.

[7] Kreher, Ralf ,UMTS signaling: UMTS interfaces, protocols, message, flows and procedures analyzed and explained, John Wiley, 2005. ISBN : 0-470-01351-6.

[8] Sumit Kasera, Nishit Narang. 3G Networks Architecture, Protocols and Procedures.Tata McGraw-Hill, 2004.

[9] Dean Bubley. Multimode wireless: The new mobility value chain. Technical report, Disruptive Analysis, September 2003

[10] G. Fay, "Wireless Data Networking," International Journal of Network Management, 8 March 1992, pp. 8-17.

[11] D.J. Goodman, "Second Generation Wireless Information Networks," IEEE Transactions on Vehicular Technology, Vol. 40, No. 2, May 1991

[12] D. Buchholz, et al, "Wireless In-Building Network Architecture and Protocols," IEEE Network Magazine, November 1991, pp. 31-38.

[13] G. Kaplan, "Data Communications--Special Guide," *IEEE Spectrum*, August 1991, pp. 22-31.

[14] G. Kleindl, "Digital Enhanced Cordless Telecommunications (DECT)," *IEEE Vehicular Technology Society News*, May 2002, pp. 14-20.

[15] J. Laiho and A. Toskala, "Overview of WCDMA," *IEEE Vehicular Technology Society News*, February 2003, pp. 13-22.

[16] WKarim, M.r. (rez).-cdma For Umts And 3g Networks,McGraw-Hill,2005,Pp 129-178.

[17] A novel view on cell coverage and coupling for UMTS radio network evaluation and design – Andreas Eisenblätter, Hans-florian Geerdes – 2005

[18] A.: Optimization methods for UMTS radio network planning – Andreas Eisenblätter, Armin Fügenschuh, Hans-florian Geerdes, Thorsten Koch, Er Martin, Atesio Gmbh, Technische Universität Darmstadt - 2003

[19] Oliver Pausch,GSM and UMTS - Excellent Past, Bright Future, Reutlingen University,2006,Pp 23-26.

Article received: 2009-07-10